

U.S. DEPARTMENT OF  
**ENERGY**

Office of  
**ENERGY EFFICIENCY &  
RENEWABLE ENERGY**

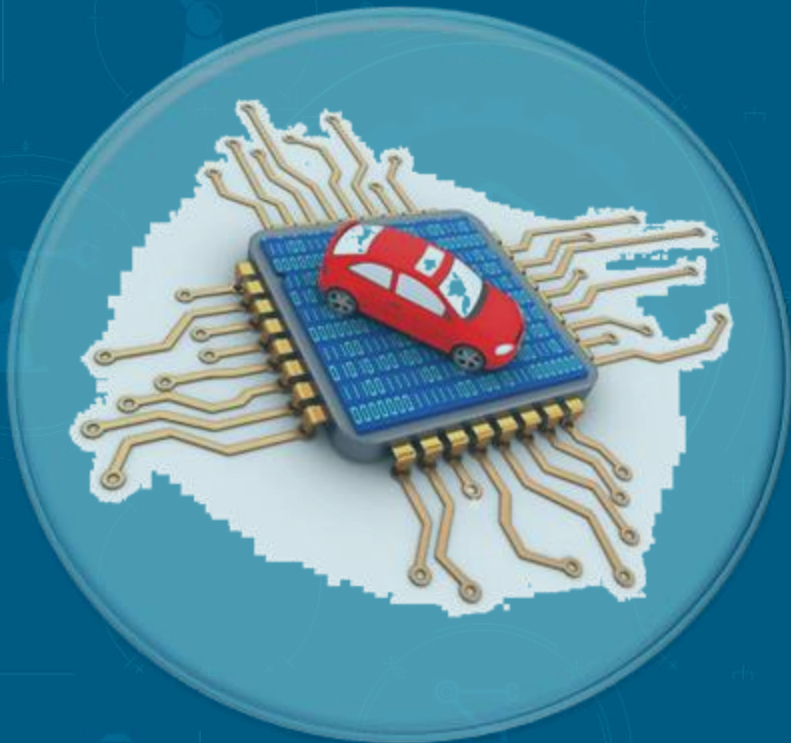
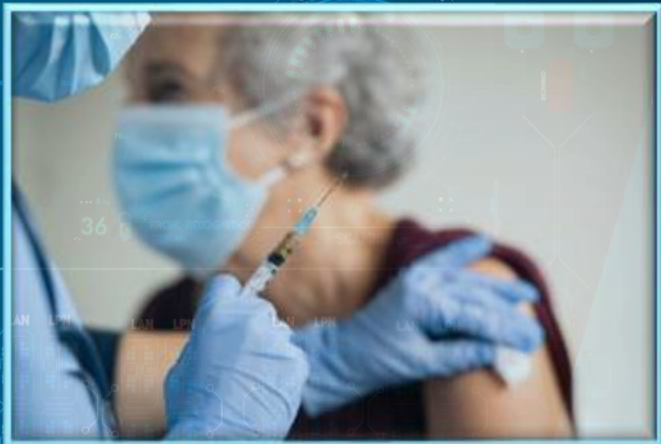
**ADVANCED MATERIALS &  
MANUFACTURING  
TECHNOLOGIES OFFICE**

**Dr. Huijuan Dai**  
Program Manager

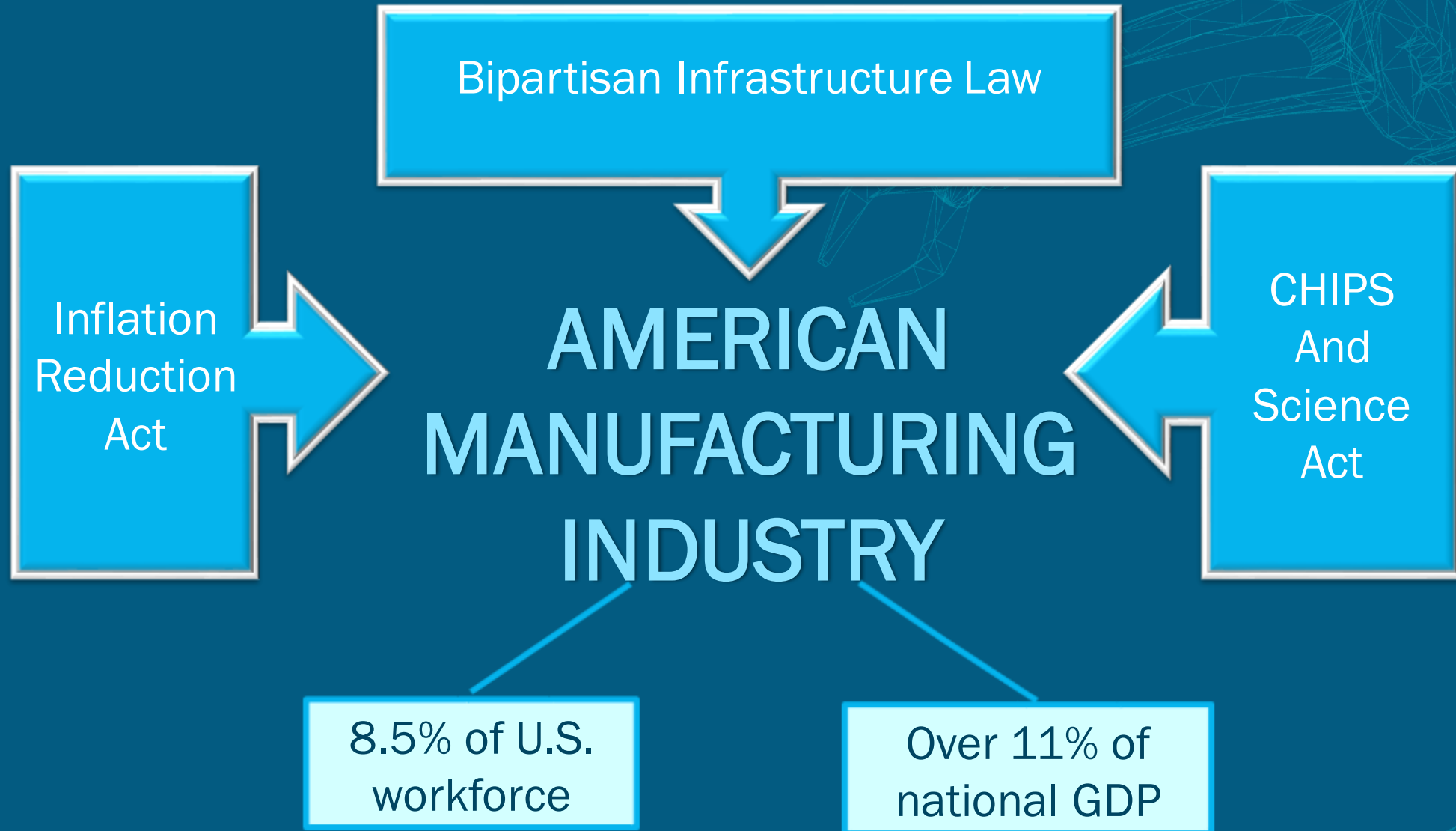


**Advancing  
DOE's Clean Energy Goals  
for Composites Manufacturing**

# The World is Changing...



# Unprecedented Federal Investment in Manufacturing



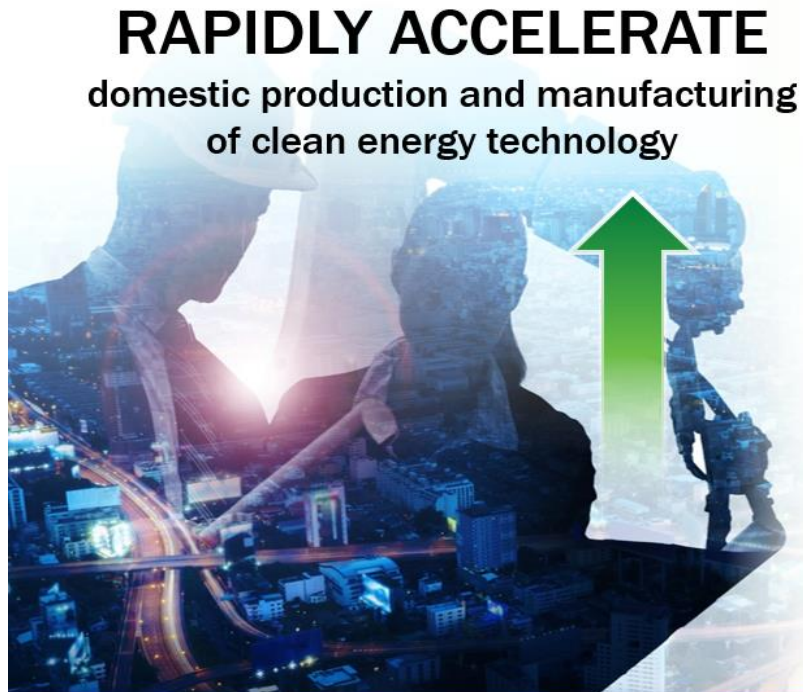
# Advanced Manufacturing Office (AMO) is Now:

## AMMTO

Advanced Materials and Manufacturing Technologies Office



Inspire people and drive innovation to transform materials and manufacturing for America's energy future.



## IEDO

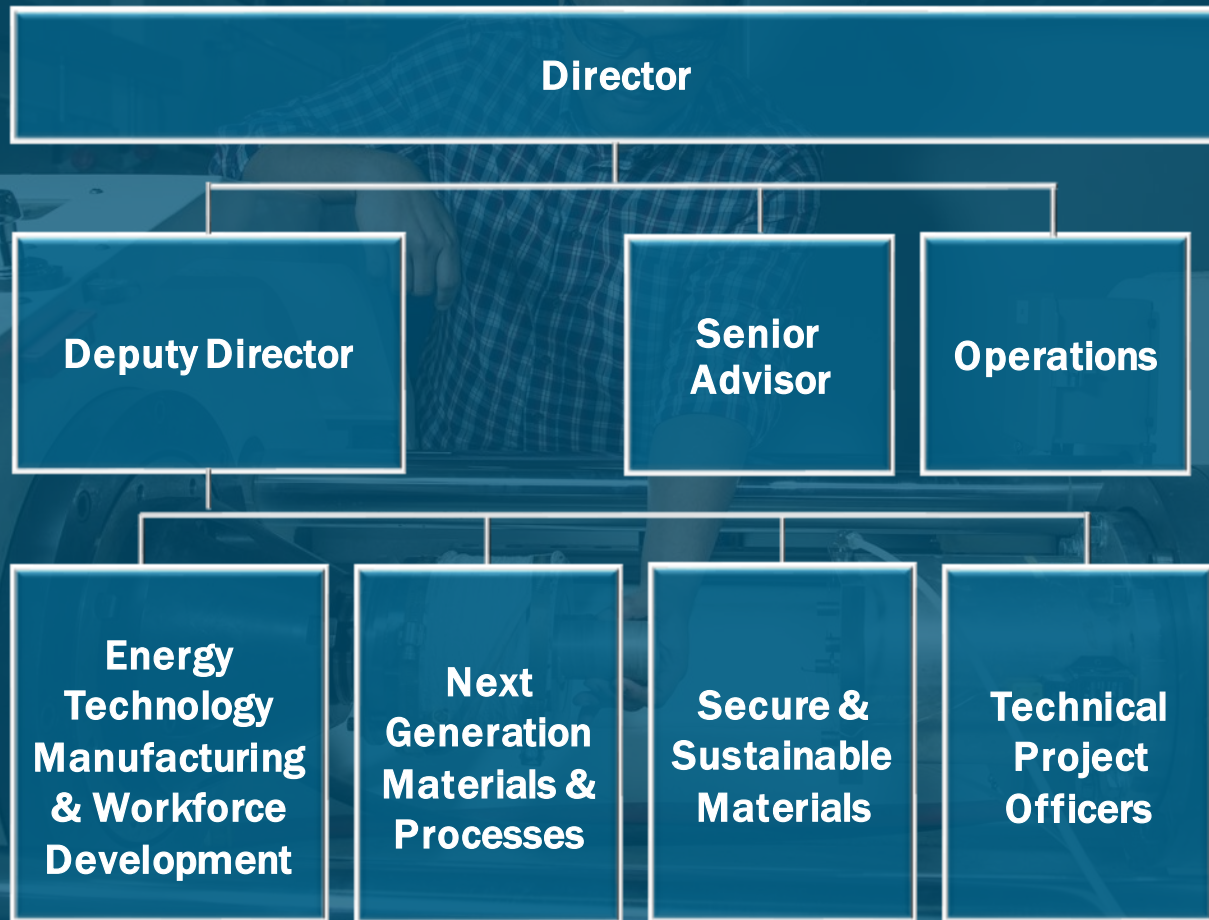
Industrial Efficiency and Decarbonization Office



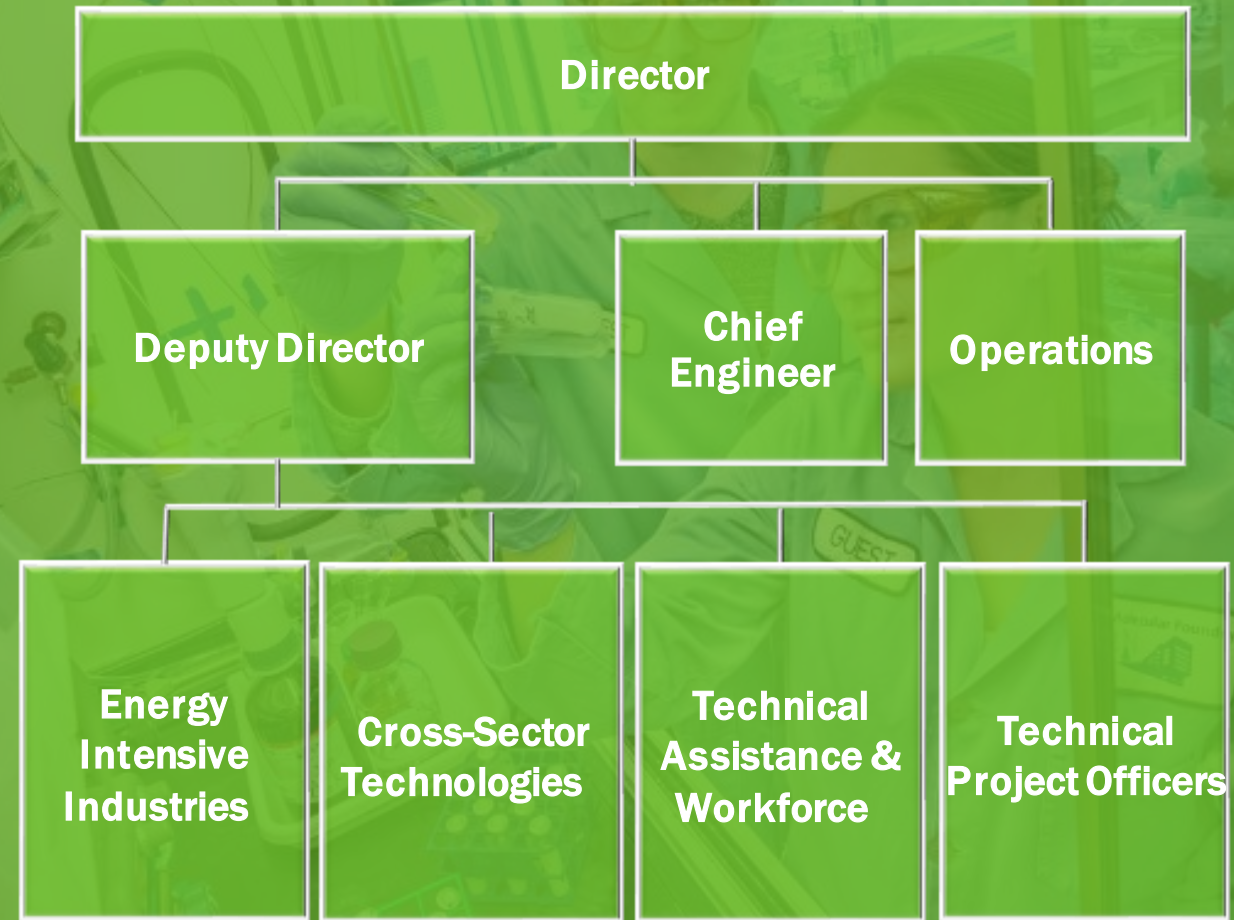
Lead the development and accelerate the adoption of sustainable technologies that increase efficiency and eliminate industrial greenhouse gas emissions.

# Catalyzing Transformation

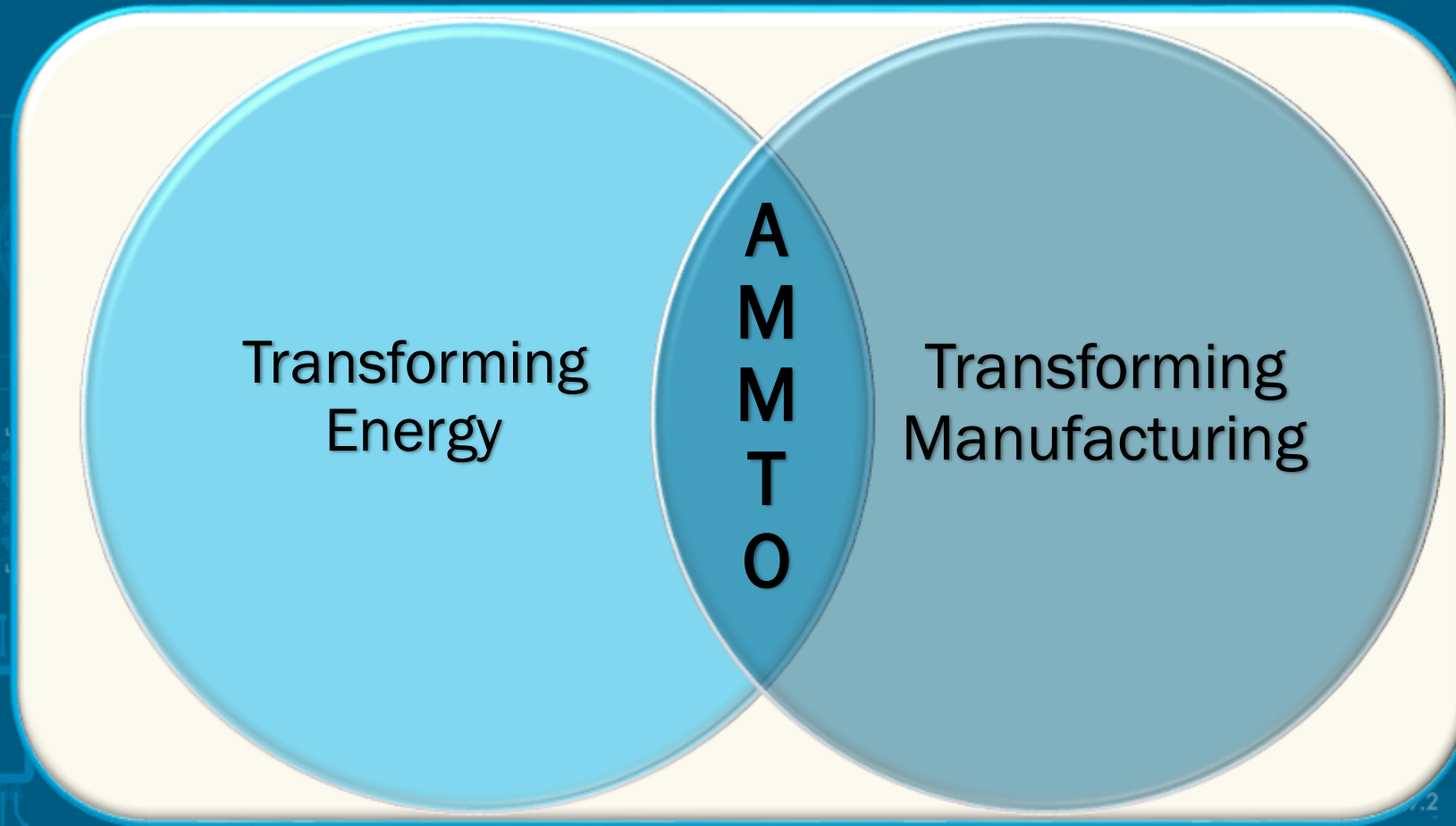
## Advanced Materials & Manufacturing Technologies Office (AMMTO)



## Industrial Efficiency & Decarbonization Office (IEDO)



# AMMTO's Unique Role in American Manufacturing



How can advanced manufacturing materials and processes help our nation to meet this critical moment and advance clean energy solutions?

# The Right Time for AMMTO

## Technology Innovation



## Inspire People



## Transform Materials and Manufacturing

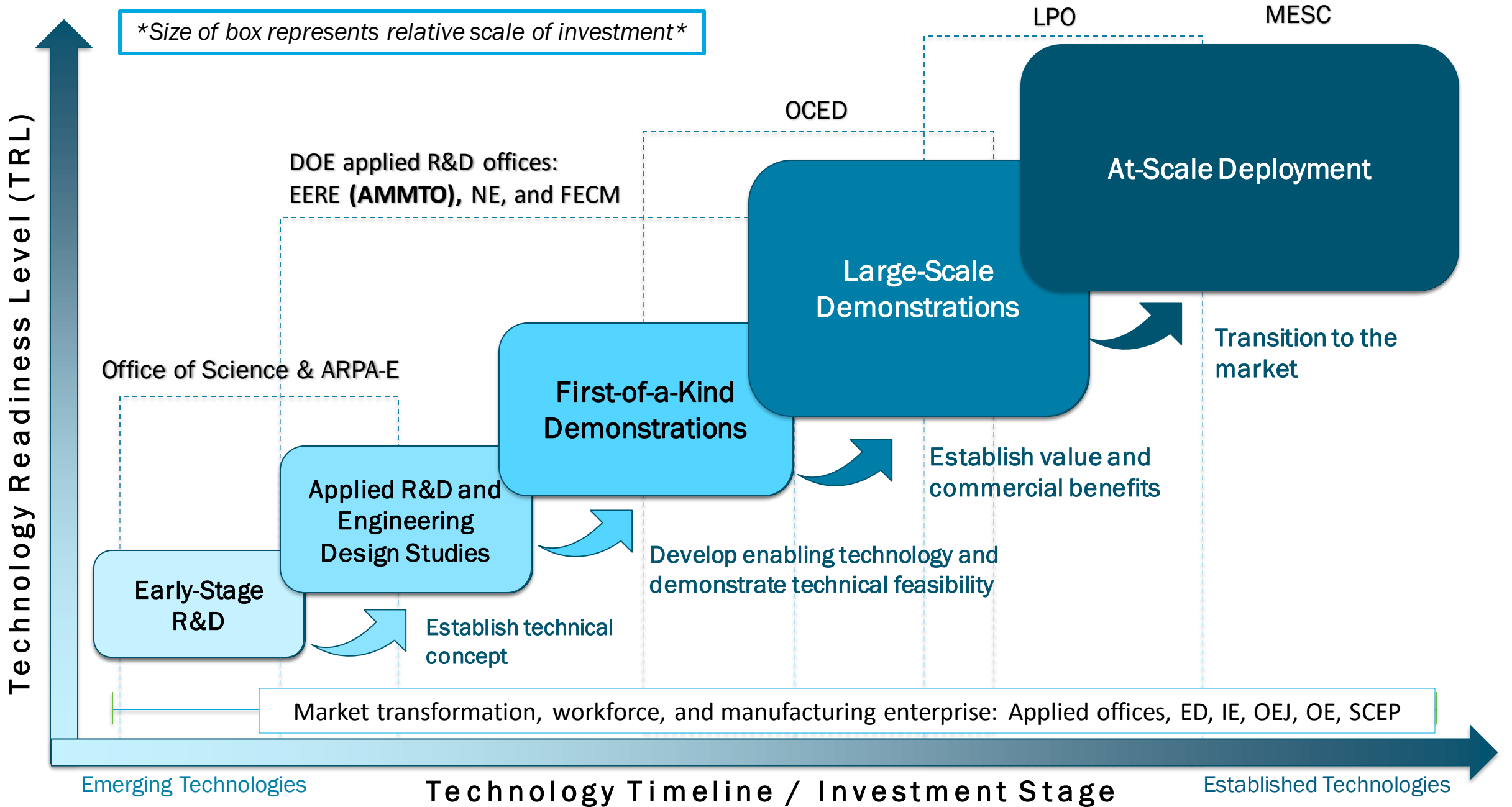


## Vision

A globally competitive U.S. manufacturing sector that accelerates the adoption of innovative materials and manufacturing technologies in support of a clean, decarbonized economy.

## Mission

We inspire people and drive innovation to transform materials and manufacturing for America's energy future.





# People Power Manufacturing



Education and  
Workforce  
Development

Innovation  
Ecosystems

Diversity,  
Equity,  
Inclusion, and  
Accessibility

# Diversity, Equity, Inclusion, and Accessibility (DEIA) Focus

We seek to create a future manufacturing workforce that reflects the diversity of Americans and ensure that all Americans benefit from a decarbonized economy.



Increasing **Diversity** in Partnerships, Applicant FOA pool, and FOA Reviewers



Using **Inclusive** Language to welcome broader participation in funding opportunities



Identifying **Equity**-related barriers that impact advanced materials and manufacturing technologies

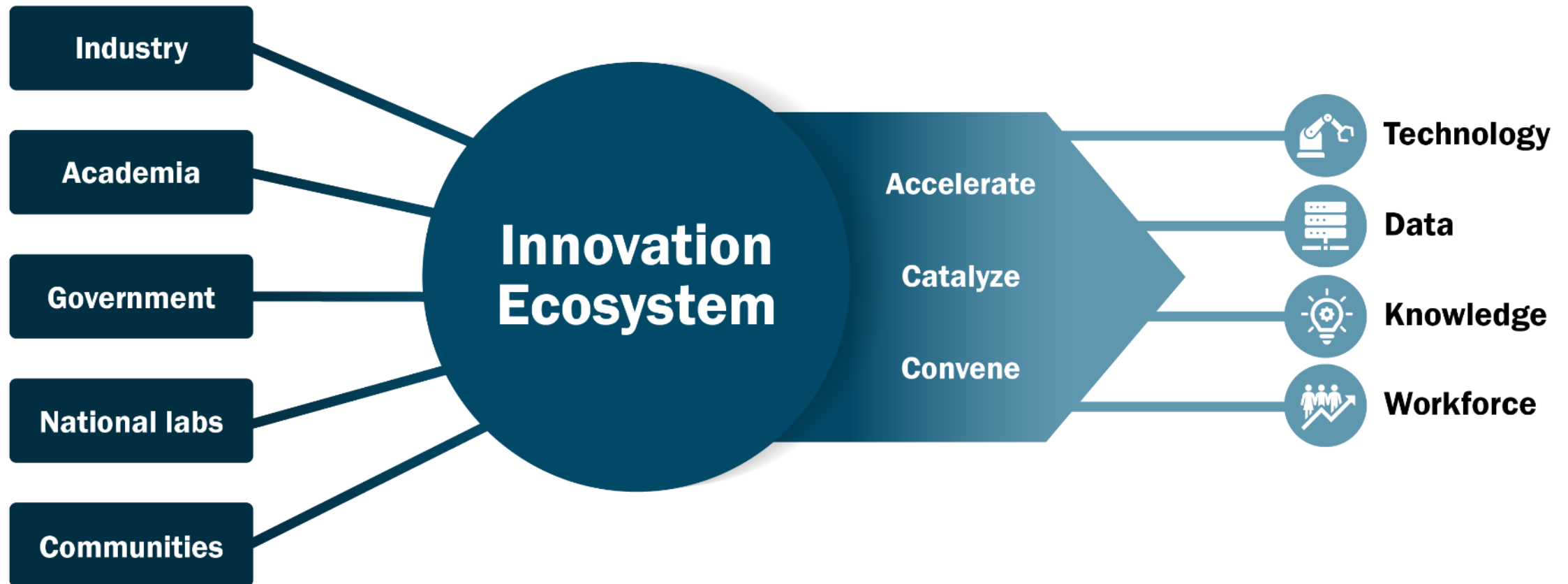


Expanding **Accessibility** for Disadvantaged Communities (DACs), including through community-based stakeholder engagement

AMMTO is committed to empowering diverse communities to have a voice in shaping the future of manufacturing. As AMMTO solidifies its identity, we are committed to amplifying best practices for DEIA internally and externally.

# Innovation Ecosystems

The evolving set of stakeholders, resources, and activities—and the relationships and connections among them—that drive technological advancement.



# Consortia Seed Innovation Ecosystems

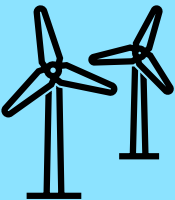


# AMMTO's Subprogram Structure

## NEXT-GENERATION MATERIALS & PROCESSES



Advanced Manufacturing Processes and Systems



High Performance Materials

## SECURE & SUSTAINABLE MATERIALS



Circular Economy Technologies and Systems

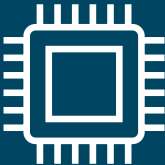


Critical Materials

## ENERGY TECHNOLOGY MANUFACTURING & WORKFORCE



Energy Conversion and Storage Manufacturing




Semiconductors, Electronics, and Other Technologies Manufacturing



Entrepreneurial Ecosystems and Advanced Mfg. Workforce

# AMMTO Budget and Subprogram Breakdown

 FY22 Enacted (\$Million)	FY23 Enacted (\$Million)	FY24 Proposed (\$Million)	
	217	184	241
Next-Generation Materials and Processes	107	90	90
Secure and Sustainable Materials	66	40	91
Energy Technology Manufacturing and Workforce	44	54	60

# AMMTO'S FY 2023 Programming

## NEXT-GENERATION MATERIALS & PROCESSES

- **Renewal of Institute for Advanced Composites Manufacturing Innovation**
- **Near Net Shape Manufacturing FOA**
- **Wind Turbine Manufacturing FOA**
- **Smart Manufacturing Workshop Series**
- **High Performance Computing for Manufacturing**
- **Conductivity-Enhanced (CABLE) Manufacturing Prize**

## SECURE AND SUSTAINABLE MATERIALS

- **Lithium from Geothermal Brines FOA**
- **Circular Economy RFI**
- **Critical Materials Education and Workforce Development Workshop**
- **Critical Materials Assessment RFI**

## ENERGY TECHNOLOGY MANUFACTURING & WORKFORCE

- **Microelectronics LC**
- **Battery Manufacturing LC**
- **Technology Commercialization Fund LC**
- **Microbattery Design Prize**
- **Energy Efficiency Scaling for 2 Decades (EES2) National Initiative**
- **Lab-Embedded Entrepreneurship Program**
- **ReCell Battery Rejuvenation LC**

## SBIR and STTR

### AMMTO Multi-topic Funding Opportunity

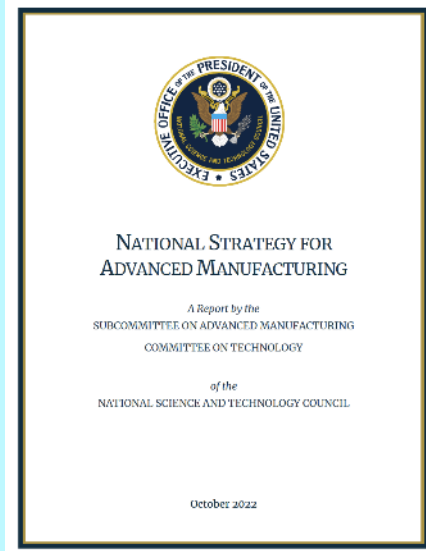
- Increased Conductivity Metal-Based Material Systems
- Harsh Environmental Materials
- Enhanced Thermal Conductivity Materials\*\*
- AI/Machine Learning for Aerostructures
- Material Circularity Regional Demonstrations
- Advanced Process Manufacturing of Electric Vehicle Cathode Active Materials at Volume

\*\* IEDO Multi-topic FOA sub-topic

# National Strategy For Advanced Manufacturing

## Vision: United States Leadership in Advanced Manufacturing

Grow the economy, create jobs, enhance environmental sustainability, address climate change, strengthen supply chains, ensure national security, and improve healthcare.



## National Goals:

1. Develop and implement **advanced manufacturing technologies**
2. Grow the advanced manufacturing **workforce**
3. Build resilience into manufacturing **supply chains** and ecosystems

## Recommendation 1.1.2.

### Clean Energy Manufacturing Technologies:

Manufacturing advances that produce cost-competitive technologies for clean energy production, storage, and utilization domestically position the United States to lead the global energy transition. Innovations such as **advanced composite** materials for wind turbine blades and efficient power electronics for charging and grid integration are needed to meet growing demands driven by the electrification of multiple sectors.

## Recommendation 1.4.1.

### High-Performance Materials Design and Processing:

Accelerate testing, qualification and process validation of high-performance materials to streamline entry into market. Develop predictive capabilities for materials behavior and performance under harsh service conditions....Systems that...have profound national security or economic impact,...typically involve operation under harsh service conditions....The development and adoption of lightweight, high strength, high conductivity, corrosion-resistant metals, **composites**, and other classes of advanced materials are important enablers for emerging manufacturing capabilities.

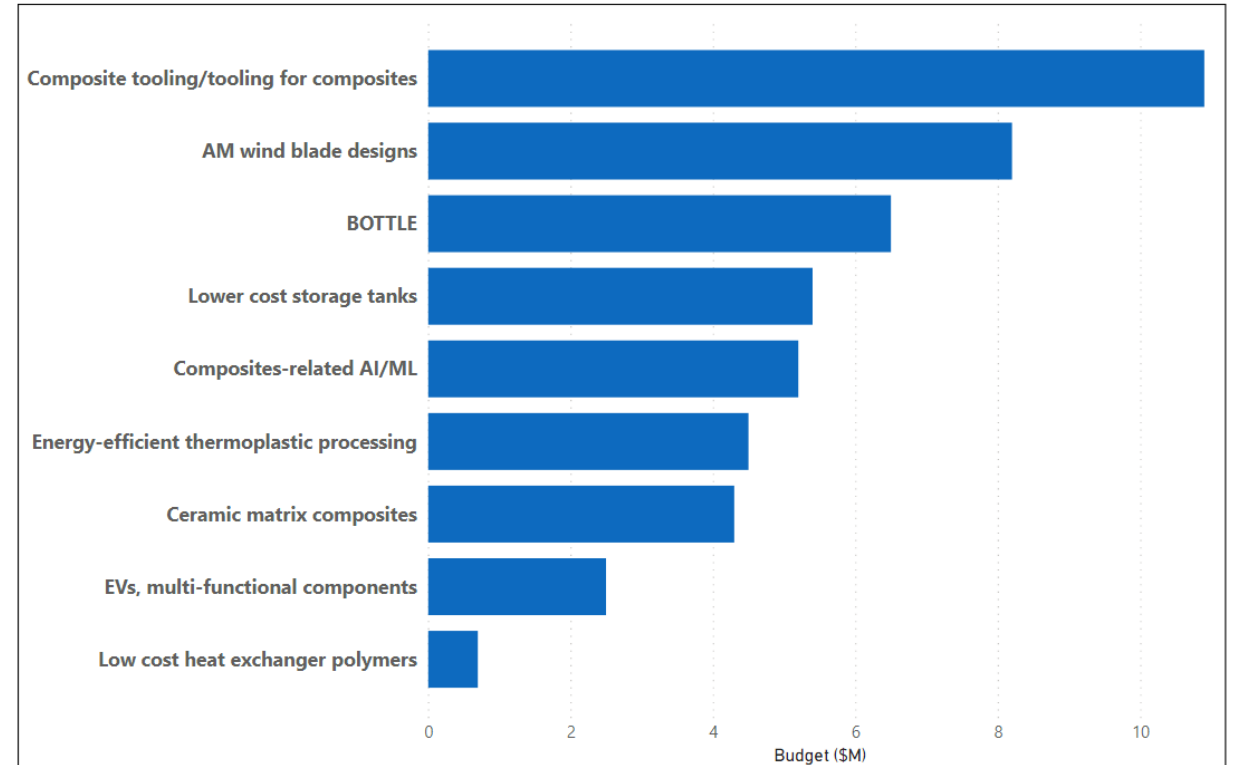
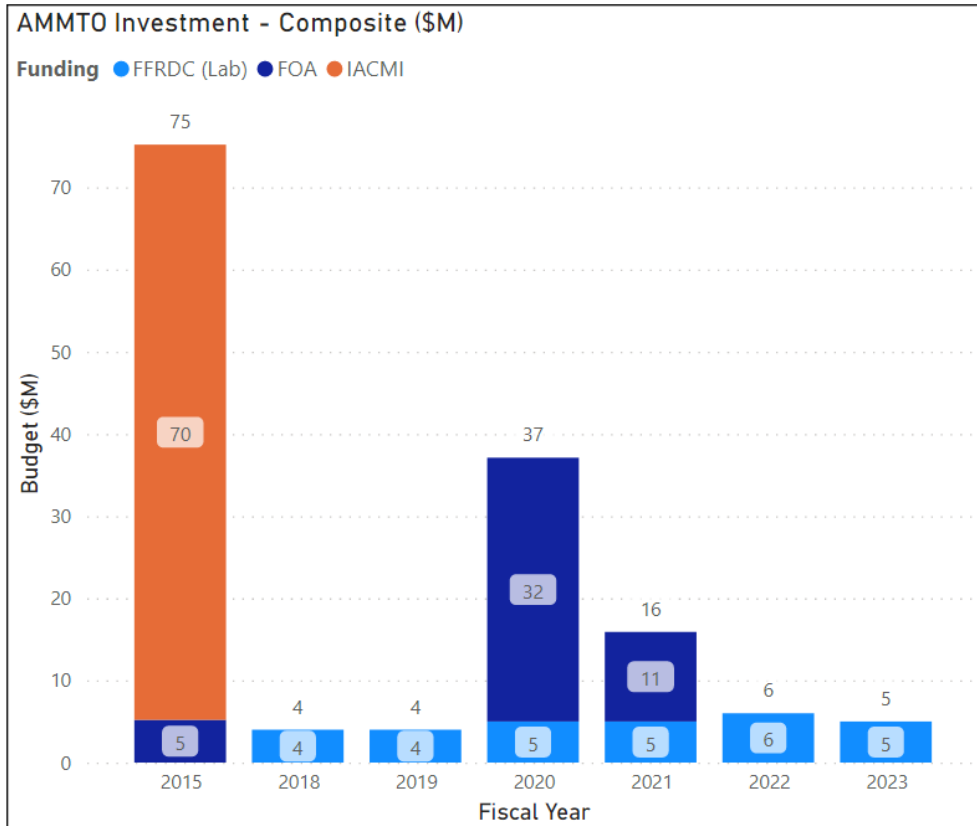


# DOE AMMTO Composites Portfolio



## Start:

2015 Quadrennial Technology Review & 2017 AMO Multi-Year Program Plan identified **Composites** being 1 of the 14 Advanced Manufacturing Technology Areas



## Composites (closely connected with other technology areas):

- Additive Manufacturing
- Advanced Materials Manufacturing
- Advanced Sensors, Controls, Modeling
- Harsh Service Conditions
- Sustainable Manufacturing
- Direct Thermal Energy Conversion

# Carbon Fiber Technology Facility (CFTF)

## Project Outline

**Innovation:** Scale-up Science Technologies for Advanced Fiber Manufacturing

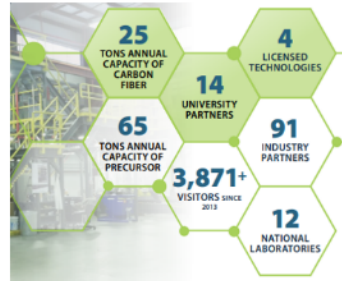
**Project Lead:** Merlin Theodore

**Project Partners:** Over 90 industrial partners, 14 universities, 12 national laboratories

**Timeline:** Oct 1, 2013 – present

**Budget:** \$5M annually

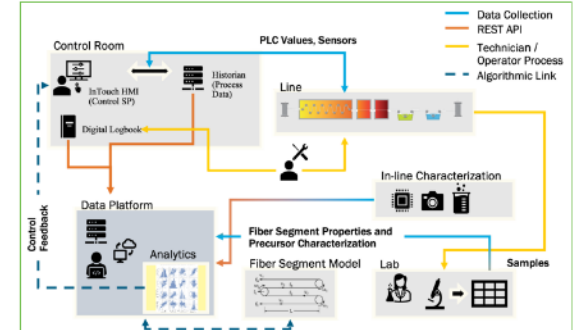
	FY21 Costs	FY22 Costs	FY23 Costs	Total Planned Funding
<b>DOE Funded</b>	\$5M	\$5M	\$5M	\$5M
<b>Project Cost Share</b>	\$123K	\$231K	\$0K	\$354K
<b>IACMI (Consortia)</b>	\$74K	\$69K	\$0	\$143K
<b>IACMI costs</b>	\$42K	\$69K	\$0	\$111K



**End Project Goal:** Develop and advance scale-up science and technologies for advanced fiber manufacturing from the research and development stage to validation and deployment, enabling domestic commercial sources of these technologies thus enhancing U.S competitiveness in advance fiber manufacturing.

## FY 23 Results and Achievements - CF Digital Data Platform Highlights

- Challenge:** Current “off the shelf” solutions do not efficiently serve CF research and production environments, leading to data being siloed and difficult to fully utilize for optimization tasks (energy reduction or quality improvements).
- Approach:** Create a custom digital data platform to enable efficient data input and retrieval at the CFTF.
- Solution:** Designed and built a software API with supporting server code and database backends that allow for:
  - digital twin modeling,
  - characterization and process monitoring,
  - data analytics.
- Result:** Our current understanding of carbon fiber specific needs and best principles of design for a data platform are being described in a software requirements specification document.



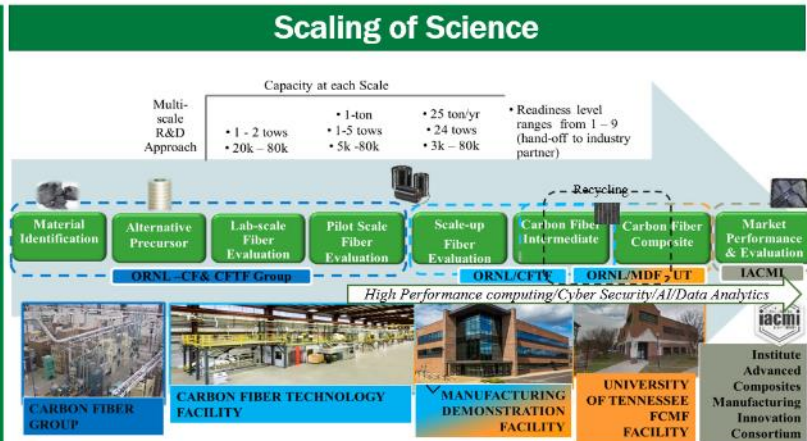
Recording a fiber segment’s history allows us to attribute characterizations to process parameters and materials and understand where energy can be saved.

**Artifacts:**

- Platform software requirements specifications
- Custom designed database schemas
- Data server software creating connections between facility data collection points
- OpenAPI specifications

## Strategic Approach - Multi-scale Integrated Precursor-to-Part Approach

- Identify high potential, low-cost alternative precursors
- Multi-scale approach to reduce the uncertainties associated with scaling & develop optimal mechanical properties of resultant carbon fiber from
- Utilize the data analytic framework developed for CF manufacturing
- Provide quantities to industrial partners for testing based on DOE approval
- Address feedback from industrial partners
- Improve carbon fiber manufacturing cost metrics



Integrator of research initiatives/strategies across the supply chain with unique supporting research facilities and capabilities, projects, technical skills, and established industry partner relationships

## Results and Achievements - Publications & Intellectual Property

**Achievements**

- Market Study completed
- API Best Practices
- > 20 publications
- Carbon Fiber Market Study/Industry Panel Identified
- 2 Copyrights/1 Mathematical model and 1 Simulation tool:
  - Bayesian Model Software copyright: <https://code-int.ornl.gov/cftf-data/analytics/boots>
  - Transport Model Software copyright
  - Mathematical Model & Simulation Tool
- >10 Invention Disclosures/Patents:
- Workforce Development - 77% Students/Interns landed jobs
  - Students – 33% Current, 40% Academia, 20 % Industry, 7% Government
  - Tech Interns - 16% Industry, 66% Government

# Manufacturing Demonstration Facility (MDF)



## Project Outline

**Innovation:** The Manufacturing Demonstration Facility Innovation Ecosystem

**Project Lead:** Ryan Dehoff

**Project Partners:** Over 250 industrial partners, 50 universities

**Timeline:** AMMTO Funded Consortium

**Budget:** \$20M Annually

	FY21 Costs	FY22 Costs	FY23 Costs	Annual
Consortium Management and Convening Industry	\$2M	\$2M	\$2M	\$2M
Core Research Projects	\$16M	\$16M	\$16M	\$16M
Industrial Collaboration	\$2M	\$2M	\$2M	\$2M
<b>Total DOE Funding</b>	<b>\$20M</b>	<b>\$20M</b>	<b>\$20M</b>	<b>\$20M</b>
<b>Project Cost Share</b>	<b>\$17.5M</b>	<b>\$14.1M</b>	<b>\$10.5M</b>	<b>\$10-15M</b>



## AMMTO & MDF Support DOE Program's to Enable Clean Energy

*MDF research is accelerating advanced manufacturing to impact clean energy*

- 1) Securing a U.S. supply chain.
- 2) Addressing affordability of clean energy technologies.
- 3) Improving energy efficiency in fabrication and application.

**DOE & EERE**

Stakeholder Engagement  
Core Projects  
Technical Collaborations



Thermal Energy Storage for Buildings: EMPOWER Wall FEMP / Buildings  
Enhanced CO2 Emission Capture: Fossil Energy and Carbon Management  
Deposition of Tungsten for Plasma Facing Surfaces: Fusion Energy  
New Materials for Efficient Transportation: Vehicles  
Digital Certification of AM for Nuclear Components: Nuclear Energy  
Wind Turbine Blade Manufacturing: AMMTO and Wind  
Affordability for Low Head Hydro Power: Water Power and AMMTO

## MDF Core R&D Results Drive Industry Adoption



Digital Factory	Powder Bed AM	Polymer AM & Composites	Large-Scale Metal	Hybrid
<p>Peregrine: AI software for real-time 3D print monitoring licensed to 30+ companies and recipient of a FIC 2022 award</p> <p>Simurge: AI-based CT reconstruction achieved improved detection capability while reducing scan time by 6X</p>	<p>3D printed Al alloys with superior high temperature performance</p> <p>Linking high-throughput thermodynamic calculations to AM process conditions</p>	<p>Scaled-up implementation of novel manufacturing technique: additive manufacturing with compression molding</p> <p>Demonstrated highly energy efficient additively manufactured mold through incorporation of heating elements</p>	<p>Single-torch deposition rates increased to greater than 35 lb./hr.</p> <p>Casting die used by Mercury Marine to make 4,000 parts</p>	<p>Complex 5 axis toolpath algorithms enabling conformal cooling</p> <p>Co-development and installation of worlds largest metal hybrid AM system</p>

## ORNL & U-Maine MDF Hub& Spoke

*Sustainable Forest Products in Additive and Composite Manufacturing Processes*



- Connects a \$2+ Billion national laboratory to local ecosystems.
  - U-Maine's Advanced Structure & Composites Center (ASCC) is the largest university-based research Center in Maine; 260 personnel.
  - Combines MDF-ORNL expertise in advanced manufacturing with UMaine innovation in forest-derived biocomposites.
  - Facilitates access to ORNL and UMaine assets and expertise to bring new, sustainable, and functional materials and processes to the market.
- Optimize the production, implementation, and manufacturing of bio-based materials to reduce dependence on fossil fuel-derived polymers and composites.
- Integrate these materials and processes into mainstream manufacturing industries to achieve carbon neutrality and clean energy in US industries.

# IACMI – The Composites Institute



## Project Overview



**IACMI-The Composites Institute**  
The Institute for Advanced Composites Manufacturing Innovation  
Knoxville, Tennessee

- Established in 2015 DOE Advanced Manufacturing Office
- One of 16 Manufacturing USA Institutes
- IACMI Mission:** Convene, connect and catalyze the composites community to accelerate advanced composites design, manufacturing, technical and workforce solutions to enable a cleaner and more sustainable, more secure and more competitive U.S. economy
- Founding partners: University of Tennessee, Oak Ridge National Laboratory
- Additional core partners: Purdue (IN), National Renewable Energy Laboratory (CO), Michigan State University (MI), University of Dayton Research Institute (OH)
- Extensive ecosystem of core partners, state economic development agencies, trade associations, professional societies, workforce partners and multiple industry participants

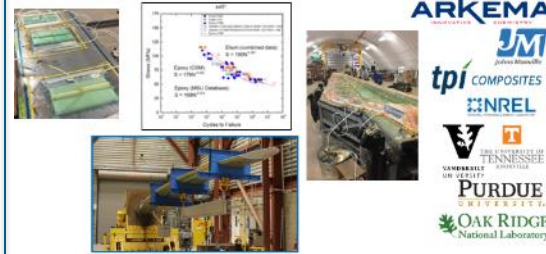


**Budget:**  
DOE Funded \$70M  
Project Cost Share \$130M  
Total \$200M



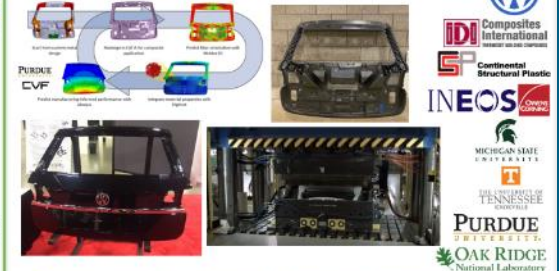
## Results and Achievements - Examples

### Recyclable Thermoplastic Wind Blade



- Novel polymerizing thermoplastic technology
- Small infusion studies, then scaling to 13m blade
- Static and fatigue testing coupon and at full scale
- Lower tooling and recurring costs demonstrated
- R&D 100 winner

### Lightweight Composite Liftgate



- Optimized design using fiberglass composite
- Sub 3-minute cycle time
- 36% lighter than steel, 77% reduction in investment
- Recurring costs 9% lower vs. steel, 37% lower vs. Al
- Qualified for future production on US electric platforms

## Results and Achievements

### IACMI – The Composites Institute 2015-2022

\$70M of DOE funding was matched by \$130M of industry, university, and state cost share

TN, IN and MI ea invested \$15M  
CO, OH invested \$5M ea

**Technology**  
\$150M portfolio  
>60 R&D projects  
25+ commercial products

**Partnerships**  
120+ Members  
Industry, Universities,  
National Labs,  
Gov't Agencies

**Infrastructure**  
\$400M Value



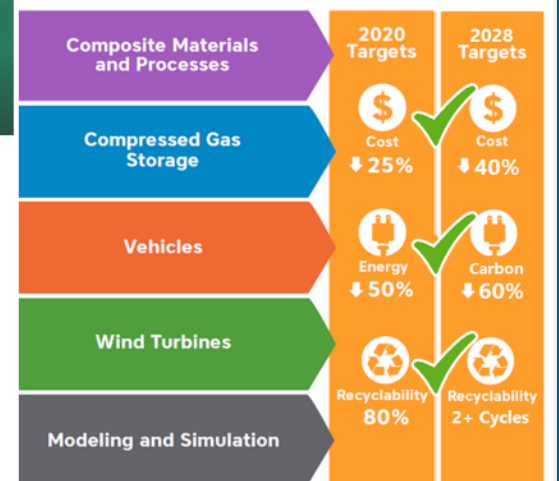
**Pipeline**  
100 Internships  
100% placement rate  
15,000 Trainees  
K-12, post-secondary  
& adult workers

**Jobs**  
3,000 Manufacturing  
Job Commitments  
by IACMI members  
partners

## Future Work, Technology Transfer, & Impact

DOE Furthers Commitment to Advancing Composites Manufacturing Through Innovation Institute Renewal

IACMI Priorities 2023-2028	
Clean Energy Markets	Wind Energy, EVs, Hydrogen Storage
Cross-cutting Technologies	Circular Economy, Digitalization, Materials & Processes
Workforce of the Future	Education and Workforce Development, DEIA
Industry health	Small & Medium Enterprises; Robust, Resilient Supply Chains; Regional Partnerships/Clusters



*The work that IACMI has facilitated is integral to DOE's mission.*

- Relevance
- Scale
- Results
- Innovation Ecosystems



# DOE Expectations for IACMI 2.0:



# Thank you!

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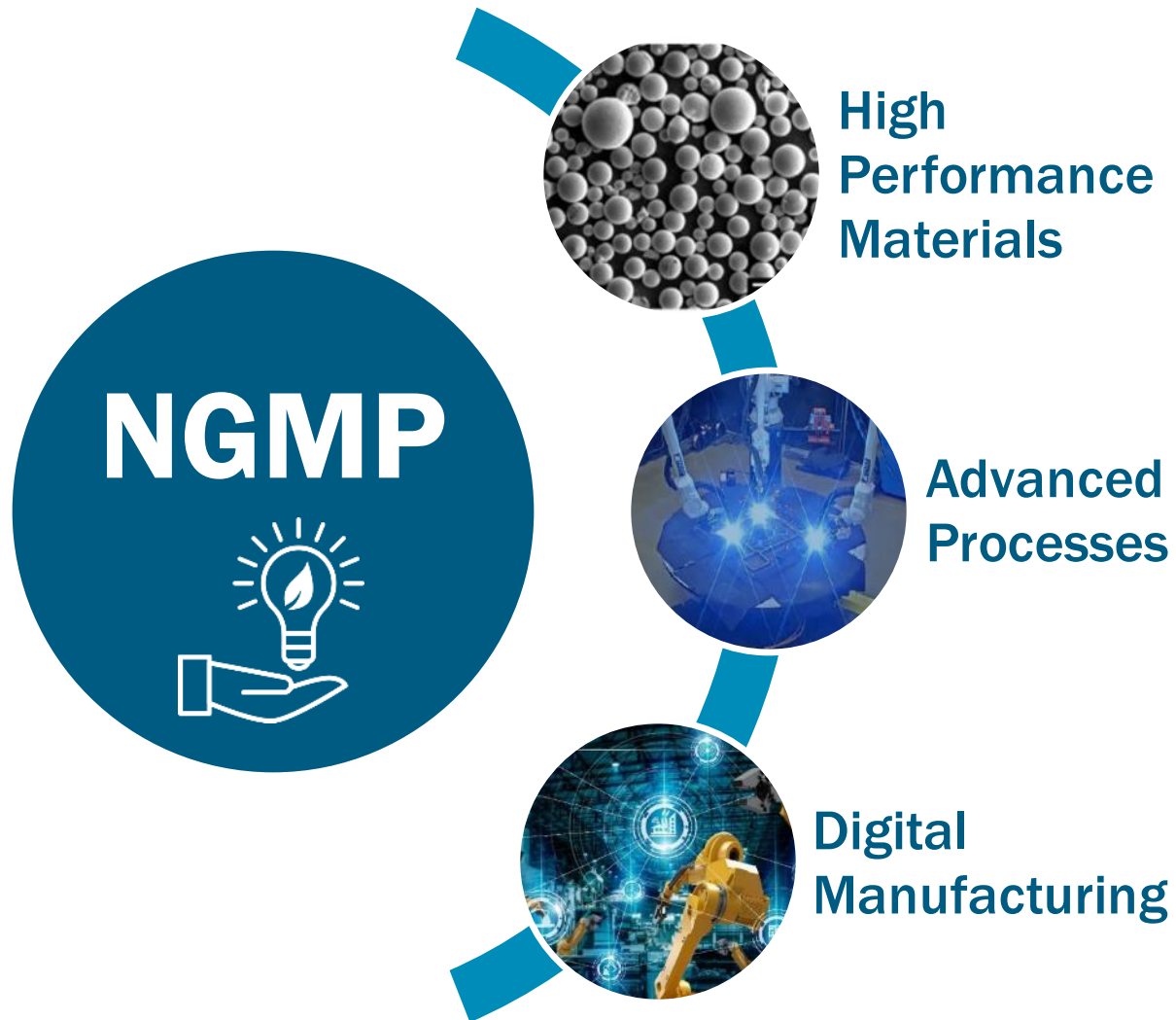
**ADVANCED MATERIALS & MANUFACTURING  
TECHNOLOGIES OFFICE**

# Back Up



# Next Generation Materials and Processes (NGMP) Program

**Objective:** Support AMMTO mission through development of **novel materials and manufacturing** processes.



- Novel materials have improved properties that improve the functionality, extend product lifetime, increase lifecycle energy and materials efficiency
- Composites, Materials for Harsh Service Conditions, Conductive-enhanced Materials
- 41 Projects (\$96M)
- RD&D Consortia: IACMI, MDF, CFTF

- Additive Manufacturing, Near Net Shape Manufacturing, Roll-to-Roll Manufacturing, Modelling & Manufacturing for Lightweight Structure, System Integration
- 13 Projects (\$28M)
- RD&D Consortia: IACMI, MDF, CFTF

- Smart Manufacturing, Cyber Security, High Performance Computing
- 4 Projects (\$1M)
- RD&D Consortia: CESMII, CYMANII, MDF
- National Strategy for Smart Manufacturing

Enhance Material **Properties** and Energy **Efficiency** of Manufacturing, Improve the Resiliency of **Domestic** Supply Chains